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Conditions Detrimental to Seed Production

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CONDITIONS DETRIMENTAL TO SEED PRODUCTION

By J. B. S. Norton and C. E. Leathers*.

Introduction.

At no point in the production of crops can greater results be obtained with less effort and expense than with the seed. It is the purpose of this bulletin to bring together the results of some minor investigations relating to seed health, and with them a summary of previous work on diseases and other conditions interfering with proper seed development. The writers hope that in addition to recording their own work, the mass of widely scattered data condensed in the following pages will be of use to extension workers and teachers, and that especially in the second part, farmers may find information that will aid them in producing more and better seed of whatever crop they may be interested in.

The question of avoiding plant diseases by planting healthy seed obtained by selection from healthy plants, or by seed disinfection, is especially important now when food production and conservation are imperative, and when seed stocks for some crops are short. We not only want good seed for planting, but our most valuable foods consist of seeds; and though in most fleshy fruits seeds are looked upon as a defect their presence is usually necessary to secure proper development of the fruit.

The bulletin is limited mostly to a discussion of the factors that affect the seeds directly. Space and time will not permit treatment in detail of cultural and climatic conditions, or diseases and insects which affect the plant as a whole, although they will of course influence the seed, as will also many hereditary characteristics. Condi-

*Many valuable criticisms have been made by members of the Departments of Agronomy, Horticulture, Botany, Entomology, etc., who have kindly read the manuscript for this bulletin.

tions that affect mainly the amount of seed produced are not usually included. Diseases carried by the seed from one crop to another, and troubles connected with pollination have been more fully treated than some of the other subjects.

At the end of the bulletin will be found a list of publications on this subject, but it is not to be regarded as a complete bibliography, but rather as a tentative list for further study by any one interested in growing, using or working with seeds. The desire to publish the bulletin soon enough to be of use this year has prevented a more thorough study of the literature of the subject.

The numbers in parenthesis in the text of the bulletin refer to the numbers of the separate works in the above mentioned bibliography where the authority for the respective statements quoted may be found. Where there has been any choice, the intention has been to cite the more accessible or later publications rather than the original. The publications cited contain references to hundreds of earlier works.

Conditions affecting the health, viability, purity and usefulness of seeds after they are mature, such as storage in too hot or too cold places, injury from dampness, molds, seed-eating insects, etc., are not specially dealt with in this bulletin, as they have received full consideration in many recent works. For further information on such questions the reader is referred to the State Seed Laboratory, located at this Experiment Station, and to the following bulletins of this Station: 96, 101, 103, 106*, 115*, 120*, 128*, 137*, 141*, 147, 155, 162, 168, 170, 179, 189*, 190, 197, 198, 200, 201, 203, 204.

PART I.—GENERAL.

The principal conditions that interfere with seed production are:

1. Hereditary defects that prevent seed formation, make imperfect seed, or seed that carry injurious characters to their offspring, such as: unproductiveness, poor quality, and low resistance to unfavorable climate and parasites.

2. Unsuitable time and place for best development, such as: too early or too late planting, unfavorable altitude, latitude, or position on the plant.

3. Variations in soil, temperature, moisture, light and other factors that injure the parent plant, reducing the number and size of seeds, or that affect directly the composition, state of maturity, vitality, and resistance of the seeds.

4. Prevention of seed formation by absence of proper pollen, self-sterility, or diseased or injured pollen.

5. Crossing with pollen from inferior or wild related plants, or from too closely related plants (inbreeding).

6. Injuries caused by animals or other plants, including insects, birds, rodents, man, fungi, bacteria, etc., whether acting as parasites

*Out of print.

or not; or by crowding by weeds or other plants of the same kind. These factors may injure the parent plant, destroy the reproductive organs or the seeds during formation, or in the case of both fungous and insect parasites, may be carried over by the more or less unharmed seeds to attack the progeny.

7. Injuries from chemicals during seed formation or in fermentation or other processes connected with harvest and storage.

HEREDITARY DEFECTS.

The whole subject of improving plants by selection and breeding might be included under this heading but is hardly within the scope of this brief treatise. All the characteristics that distinguish one variety, species or strain from another are transmitted from the parents. The seed consists essentially of a young plant which has grown from an egg cell of the mother plant after being fertilized by a sperm cell from a pollen grain of the male plant, and which while yet in an embryonic condition has separated from the mother plant with its surrounding parts and often with different kinds of reserve food stored in or around it, and drying out becomes a dormant reproductive body. If nothing has occurred during the formation of the seed or while it is dormant, to impair its vitality, with proper temperature and access to water and oxygen, the young plant will begin to grow again and will reproduce more or less closely the characters of its parents, depending on the conditions under which it grows.

Most kinds of plants, especially those that have not been grown from seed and carefully selected to conform to a certain type and preserved from indiscriminate crossing, are a mixture of many different types. It often takes several generations with self-pollination to get a fairly pure selection from such a mixture, but a limit is soon approached beyond which selections can make no further difference (165).

The length of time after maturity until seeds will germinate is a hereditary factor that may, however, be varied some by other conditions. The per cent. of ''hard'' seeds of legumes with difficult germination is usually greater under dry conditions (223) and some seeds may be germinated more easily if not allowed to become fully dry (68). A hereditary tendency exists in many trees to produce more seed on alternate years or even at longer intervals, but these variations are so complicated by other differences due to environment that they are not certain.

There is a hereditary correlation in fruits between the size of the fruit and the number of seeds but this varies much with different species (22, 119).

Other hereditary defects will be considered in Part II. Many of the varieties and strains resistant to the attacks of parasites or to other injurious conditions are also listed. More of these are being

bred or discovered annually. The opportunity for any grower to select resistant strains of many crops from his own fields is one that can be grasped with much chance of success. Special works on breeding and selection are referred to under the crop headings in Part II.

Position on the Plant.

The position on the plant or in the fruit, occupied by a seed sometimes makes a difference in its size, vitality or other character, but much less than is often supposed. The earlier and later flowers often do not produce seeds on account of arrangements that prevent their receiving pollen, and in many cases the later produced seeds are smaller or weaker or have less opportunity to mature. Those produced at different times on the same plant are likely to have entirely different male parents (46, 51, 85, 93, 262, also under corn and wheat).

Foreign Seed.

There is a general belief, probably based on facts that apply to a few crops like potatoes, cabbage or spinach, that are grown extensively in regions not adapted to their seed production, that seed obtained north or south or somewhere away from home is better than home grown seed. Many experiments made at this Experiment Station and elsewhere have shown that in nearly all cases the contrary is true (94, 132, 156, 192, 215, 254, 262, 278). Sometimes other considerations make it more advisable to import seed, at least more profitable.

The conditions that favor the growing of seed elsewhere are: more favorable climatic conditions for some crops, less danger of crossing where grown on a large scale, sometimes freedom from diseases prevalent at home, better trained growers and more economical production where seed growing is the sole interest. The advantages of growing seed at home are: better care, personal control of selection for the desired type, adaptation to local conditions, less outlay of cash for purchase, no danger of importing new diseases.

There should be an opportunity for some one in each neighborhood to specialize in seed growing for that locality (305).

Immaturity.

Seeds not thoroughly ripened contain more water and for this reason are subject to many kinds of injury that dry seeds escape. Moist seeds are more susceptible to injury by both cold and heat, and also to injurious gases and liquids. Townsend, at this Experiment Station in 1901, found that hydrocyanic acid would affect damp seeds much more than dry ones (273). Although moist seeds of many plants are easily killed by freezing, perfectly dry seeds have been subjected to temperatures of 100 to 200 degrees C. below freezing without injury (40, 270).

Damp seeds are very susceptible to the attacks of fungi and bacteria, and if stored in bulk are almost certain to heat and spoil from fermentation by microorganisms or through their own physiological activities. They may also start to grow and then perish from lack of conditions for further growth. Seeds that have just started to sprout and are then dried again may not be killed, but usually do not retain their vitality as long as fresh seed (see tomato).

Harvesting the parent plant before the seed is fully mature does not always injure the seed. Our grains are usually cut before fully ripe, but if not cut too early there is sufficient moisture in the stalk to keep the rapidly drying grain growing until its ripening processes are sufficiently complete.

The success of many weeds, such as purslane, dock, garden weed, and winter cress is due largely to their ability to mature seeds quickly, and they contain enough water to bring seeds to maturity on plants cut when just in bloom (23, 199). With many crops that must be harvested with seeds in all stages of development a higher percentage of mature seeds can be obtained by pulling or cutting the whole plant and drying under conditions that will save the ripe seed that would have shattered if left in the field. Planting and harvest have to be adjusted to the habits of the different crops in order to get the best yield of ripe seed. (See celery, Sudan grass and other crops.)

Seeds dried before full maturity may germinate, but generally do so more slowly and do not make strong plants, though they may fruit earlier (7, 105, 269, also tomato and cowpea).

In harvesting and storing seeds one of the most important operations with practically all crops is to get the seed dry before putting it away in bulk and to keep it dry and well ventilated. Seeds do not dry readily in vessels even if low and open at the top, but do better if spread out thinly in a dry place on cloths or wire netting. They need to be stirred frequently, even after apparently dry (279).

The number of years seeds retain the power to germinate depends much on their moisture content, but varies greatly in different species. Most vegetable seeds if kept dry live under normal conditions for five to ten years, parsnip and onion are shorter lived, and seeds of some tropical plants live only a few days (76).

Premature Germination.

Seeds sometimes germinate inside the sound fruit which bears them, as is occasionally seen in oranges, lemons and watermelons (66). Under conditions of abnormal humidity, grain and many other seeds will be injured by germination beginning before harvest (88). We have found that tomatoes, cabbage and other seeds will germinate under water and tomatoes germinate in the fermentation liquid when they are being cleaned from the pulp if left in too long.

Injurious Effects of Soil and Fertilizer.

It is well known that certain soil conditions are unfavorable to seed production. Cultivation, moisture and fertility favor vegetative growth and retard maturity. Nitrogen as a rule seems to retard seed production and phosphorus hastens ripening (94, 159, 281, 338, see also under wheat). There is some evidence that a change of hereditary characters may take place on soils of high fertility (253, 278, 296).

Injury Due to Low Temperature.

In fruit trees, one of the commonest causes of seed failure, and consequently of fruit production, is the killing of flower buds by low temperatures in winter, or still more easily by frosts after opening in the spring. Often the only indication of the injury is the darkened center of the bud or flower, so characteristic of the winter killed bud of stone fruits.

But cold weather not necessarily low enough to freeze, often prevents seed formation, possibly by hindering the pollen from germinating (107, 233) or even its formation or discharge from the anthers (see tomato). In some cases bees that are necessary for carrying pollen may be prevented from working by cold weather. Some fruit trees escape injury by frost by their late blooming habit; they also vary in resistance to cold.

Cold weather in autumn is the chief cause of immature seeds and the principal source of injury to grain not yet thoroughly dry. See corn and wheat (182).

Injuries Due to High Temperature.

Often plants adapted to cool temperatures will not produce seed in a warm climate (see oats, lettuce, winter cress). Seeds are sometimes killed by artificial drying or by heat applied for killing insects, or by heating due to storage before dry. Seeds of the mustard family heat easily in bulk. Attics are usually too hot for seed storage (279).

Seeds full of moisture are killed at about the same temperatures as other parts of plants, near 50 degrees C., but varying with the different species. Dry seed in hot water will stand a little higher temperature; some kinds have been exposed to boiling water for a short time without injury (50, 167).

Lack of Pollination.

Occasionally flowers may produce fruit or even seeds without pollination (67, 87, 124), but the great majority must be pollinated in order to bear fertile seed.

In some plants pollen put on before the stigma is ready for it may be really injurious to the flower (124), in other cases it simply waits

until the right stage of maturity (12).

Pollination may be prevented by the absence of the plants that produce it. In some plants like date, fig and willow the pollen is produced on separate trees from those that bear the fruit and seed. In others like corn and castor bean it comes from separate flowers on the same plant. But in most plants, though borne in the same flower, position, time of maturity or other devices prevent the pollen reaching the stigma of the same flower, so that it can only take part in seed production on a different flower or plant, where it must be carried by wind, bees or other agents. In the case of wheat, tomato and some other plants nearly all the seed is produced with pollen from the same flower.

If the natural means of transferring the pollen to the stigma is absent, seed production will be interfered with. Rain often wets the pollen and causes it to burst or to germinate out of place or may prevent its discharge from the anthers. Weather conditions also prevent insects from making their visits and carrying pollen. (106, 233, also tomato).

Inbreeding.

In some kinds of plants seed is continually produced with pollen from the same flower without deterioration. In most cases crossing with pollen from a plant of even the same variety gives reduced vigor or productiveness. Even with plants that are generally self-fertilized it has been found that crossing with another variety increases the yield in the next generation (89, also tomato and corn).

Self-Sterility.

Many plants will not produce seed with their own pollen; or in case of most of our cultivated fruits, from pollen of the same variety, which is really the same thing, as the individuals of varieties propagated by buds, grafts or cuttings are only parts of the one original of the variety. But this self-sterility is somewhat variable, some varieties of the same kind of fruit possessing it and others not, and even the same variety may be self-sterile in one year or location and self-fertile in another (163, 261, 309, 310).

Self-sterility is usually the cause of single plants or trees with no others of the same species near, not making seed or fruit.

Crossing or Mixing.

Where two varieties or species cross there is rarely any indication of the male parents influence seen in the seed resulting from the cross, and still more rarely in the fruit that contains the seed. There are, however, marked changes in color and other characters in hybrid corn grains due to the pollen. Any deterioration from bad crosses often does not show even in the plants that grow from the hybrid

seeds, and is only seen in the second generation. But the first generation will show various combinations of the two parents, but generally some characters of one or the other will be suppressed until they come out more or less separate in the second generation (16, 83).

Many of our cultivated plants have nothing to prevent them from crossing with other varieties of the same species growing near them, or even with wild relatives. There is rarely any crossing with other species, for example, there is no danger of watermelons, muskmelons, pumpkins, or cucumber mixing with each other, although the varieties of any one will cross with other varieties of the same kind (see cabbage, corn, wheat, squash, etc.)

Accidental mixture of seeds, either in the soil or before sown, is often the explanation of apparently novel cases of heredity, such as oats or wheat turning to cheat (240).

In one wishes to get pure seed of any variety that crosses easily with others, it must be grown a quarter mile or more away from related varieties, or protected by enclosing in bags that will keep out pollen, and the right kind of pollen applied by hand. Wheat varieties rarely if ever cross, other grains usually do. Legumes, as a rule, do not cross easily.

Injury by Animals.

Insects are the principal animals hindering seed production. Rodents and other seed-eating animals do most of their damage after the seed is mature. However, birds eat a great deal of seed before harvest, but most species of birds are of more benefit than harm, because of the large number of injurious insects they consume.

Pasturing the grass and grain fields in winter or spring may reduce the seed yield.

Some kinds of seeds seem to be especially resistant to injury while passing through animals that have eaten them intact. Oswald in Bulletin 128 of this Experiment Station (207) showed that the seeds of plants of the tomato family belong to this class, and we have observed so many seedlings of horsenettle, Jimson, etc., developing in manure and so few elsewhere that it looks like the manure acts as a special stimulant to germination.

The injuries from weevils, midges, thrips, etc., will be discussed in Part II (65, 74, 139, 218). Weevils may destroy a considerable portion of a seed without killing it, but the resulting plants are often weak (95).

The injuries caused by man in various farming and other operations are too numerous to mention. Cracking and splitting grain and other seeds in threshing must be prevented as far as possible, though some is unavoidable. The stamens and corolla are often removed in crossing operations without apparent effect on the set of seeds, but such operations may cause the bloom to fall (178). Sometimes it is difficult to get a set of fruit under the paper sacks used to prevent accidental crossing.

Injury from Plant Parasites.

Parasitic smuts, rusts and other fungi may destroy or injure the whole plant, and thus reduce seed production. The control of such diseases is discussed in the usual works on spraying, etc. We are concerned here with those that attack more directly the reproductive parts. Fungi may injure the flower (97) and its parts or the seeds themselves and weaken or injure them; or seed that is apparently sound may carry the parasite inside or upon the surface ready to attack the young plants that grow from it.

A large number of diseases of cultivated crops have been found to be seed carried, in some cases, more by accident, but in others like the smuts, as practically the sole method by which the disease is transmitted to another generation of host plants (15, 32, 146, 243).

Seed Disinfection.

The practice of seed disinfection to prevent the transmission of fungous diseases has been so well developed and so successful that it should become a regular agricultural practice. It would no doubt pay to disinfect all seeds before planting as soon as methods have been developed that will insure the seeds against injury by the treatment (111).

Many substances have been used for seed disinfection. Copper sulfate was used to prevent grain smut even before it was known that the disease was due to a parasite. Hot water is a very effective treatment and has an advantage over chemicals applied to the surface of the seed, in that it is effective for all internal parasites whose thermal death point is lower than that of the seed. Formaldehyde and corrosive sublimate are more convenient to use, and are now the most commonly used seed disinfectants, especially the former, as the latter is a more dangerous poison to animals (6, 157, 328). It is better to wash seed in water after the use of disinfectants, and to dry the seed if it is not to be planted at once.

The length of time that any disinfectant should act on the seed and the best concentration for any period of time must be determined for each kind of seed. So far as they have been determined, the treatment for each crop will be found in Part II.

The question of injury to the seed from chemicals used in seed disinfection is an important one and a vast amount of work has been done on the effect of such chemicals upon seeds (6, 26, 30, 65, 78, 84, 123, 142, 143, 175, 235, 273).

Seed Selection for Disease Control.

In addition to disinfection, care in saving seeds if possible from fields, or at least from plants, free from disease, will not only get rid of the disease carrying seeds, but will tend to build up resistant

strains if from disease free plants in fields with many infected ones. The more their neighbors are diseased the greater the possibility that the healthy plants are resistant rather than chance escapes (307, 316).

Competition.

One of the most injurious things that crop plants have to contend with is competition with weeds and with other plants of the same crop if they are grown too close together. The effect on the seeds is seen chiefly in reduced yield, but under these conditions of restricted food, water, etc., the seed is often poorly developed.

Competition between other fruits on the same plant results in the suppression of many fruits and seeds or the deterioration of all, and overproduction must be avoided for the best results with seeds as well as with fruit (213).

Size of Seeds.

The size of the normal seeds varies considerably with the species. Some large seeds like those of the cocoanut weigh more than a pound, while it takes more than 5,000,000 tobacco seeds to make a pound and some orchid seeds would run more than 200,000,000 seeds to the pound (199). The seeds of any one kind of plant do not vary much in size as compared with the variation in size of the plants. Starved plants a few inches high and only capable of maturing one or two seeds will produce seeds only a little smaller than luxuriant plants of the same kind bearing several hundred thousand seeds. Nevertheless seeds do vary some in size due to a variety of causes.

A great many experiments in many different places have shown that as a rule the larger seeds make larger plants and give greater yields, so that anything that results in smaller sized seed is a disadvantage (72, 108, 112, 258, 302). There are some exceptions to this general rule (117, 118, 166). The size of the embryo may be more important than the seed size (285).

Seeds of higher specific gravity germinate better than lighter seeds (52, 170). Many of the small or defective seeds are caused by diseases and improper pollination. Most of these light and diseased seeds can be fanned out, or floated out by putting the seed to be graded in water, and the seed can often be graded to any desired density by using a salt brine of the proper strength and then washing immediately after treatment so the salt will not impair the seed vitality (158).

Chemical Injury.

Sprays have to be used with the greatest care on plants in bloom, as the chemicals used generally kill the pollen as easily as the fungus spores. With many crops, such as tomato, which produce flowers daily for a long period, the few lost from spraying will not be missed, as others take their place the next day. In most cultivated plants,

many times more flowers are produced than are able to mature fruit, so that a fruit tree sprayed when a few of the flowers are open should make a better crop than if some of the flowers had not been killed by the spray, owing to the protection of the unopened ones from fungi or insects. The chief danger is in killing bees. See also under seed disinfection.

Carbon bisulfid, used for fumigating seeds for insects, will not injure seeds even if poured directly on them, but fumigation over a day or two in tight containers is apt to lower vitality (142, 279).

Seeds are rarely subject to injurious action of gases during their formation, but in such cases are subject to injury as are other growing parts of plants (142, see also under immaturity and seed disinfection).

Fermentation.

When seeds of fleshy fruits and vegetables are saved in large quantities, they are often fermented out of the mass of pulp. If left in the fermented mass too long the seeds may be discolored and sometimes the vitality lowered by the products of fermentation and by the moulds and other organisms growing in the liquid.

The results of our experiments on the effect of different lengths of fermentation of tomatoes and at different temperatures is given under tomato on a later page. The effect on other seeds is known only in a general way, but usually much less than the limit of injury is necessary to free them from the pulp.

General Rules for Raising Good Seed.

1. Have the seed stock used true to variety; pedigreed if possible.
2. Give the best conditions of soil preparation, fertilizers, planting and cultivation to produce the best yield, but avoid too much nitrogen in the soil or any other conditions that would lead to vegetative growth at the expense of seed yield.
3. Before blooming, go over the fields and destroy any inferior or diseased plants, plants of other kinds that might contaminate the seed, and any plants that are not true to the desired type, and rogue still more after the plants are far enough along to show their fruit and seed characters.
4. Prevent cross-pollination from parents whose characters are not desired in the progeny.
5. Allow self-pollination when this will not cause deterioration, and cross with desirable varieties to increase productiveness or vigor.
6. Plant at the proper time to get the largest amount of seed matured, and harvest crops that continue to produce seed over a long time, at the best time to get the smallest proportion of immature seed.
7. Destroy parasitized plants in the field and separate out diseased seeds by fanning, hand picking, etc., and disinfect the seed before planting.

The details of the means of accomplishing these results, so far as known will be found in the following pages under the various crops or in the publications cited at the end of the bulletin (see especially 10, 33, 159, 279).

PART II.—CONDITIONS AFFECTING SPECIAL CROPS.

In the following section the diseases and other conditions interfering with normal seed production in the principal crops is discussed. More attention is given to those grown in Maryland and with which work has been done at this Experiment Station, but notes on a number of plants of minor importance have been added.

Alfalfa.

Seed does not set well in the East as compared with the drier Western alfalfa districts (184). The setting of seed is dependent on pollination, usually from the same flower, which is accomplished by the parts of the flower under tension releasing the pollen suddenly. If this is not done in the natural way by insects, etc., the pollen can be released artificially, at least on a small scale (1, 326, 334).

Like many other legumes, some of the seeds are "hard" and germinate with difficulty. More hard seed is produced in dry climates (223). A chalcis fly prevents the maturity of some seeds. For control see clover (280).

The old tradition that seed from another locality is better, has had additional disproof at this Experiment Station. Nash (192) published in 1907 the results of tests of alfalfa seed from various European and Asiatic countries and from other States. The foreign seed made less hardy alfalfa than the American grown seed, but that from the Northern States was hardier than that from seed grown farther south. Graber, in Wisconsin in 1917, reported that alfalfa from northern grown seed did not winter kill less than that from southern grown seed (109).

Apple.

Injury to the pollen or the young fruit by late frost or cold winters, rain and other causes; lack of bees to carry pollen; seed chalcids, (69, 73), codling moth and sometimes other insects; overbearing the previous year; self-sterility of some varieties; and hereditary variations in the seed number (86, 87) interfere with apple seed production (11, 12, 67, 70, 106, 233). The bulletins of Ballard and Sandsten treat of many difficulties with the pollen and with pollination.

McCray (178) found that removing the petals decidedly reduced the set of fruit.

Ballard, in Bulletin 178 of this Experiment Station, has shown that some varieties escape frost injury by their late blooming habit, there being 24 days between the earliest and latest apple flowers.

Asparagus.

The seed bearing plants very rarely produce pollen, and seed cannot be grown without pollen from the male plants. In nature seed is rarely set without the aid of bees and, of course, varieties intercross freely when close enough together.

Seed is likely to shrivel if picked before fully ripe. Smaller seeds generally make much weaker plants.

Reading Giant, Argenteil, and Palmetto are rust resistant varieties and other better resistant kinds have been bred in recent years by J. B. Norton in the United States Department of Agriculture (112, 198).

Barley.

The principal barley diseases associated with the seed are the smuts. The loose smut fungus, *Ustilago nuda*, not only converts the flower and seed rudiments into a dusty black mass of spores, but these spores infect the young grain like the loose smut of wheat does. The hot water treatment for this smut was tried at the Maryland Experiment Station as early as 1898, and resulted in a 15 per cent. increase in the yield (188). The grain is soaked four to six hours in cold water and then drained and dipped fifteen minutes in water at 126 degrees F., barley requiring a few degrees less than other grains, but a lower temperature than 124 is not effective. For full directions see Bulletin 200 of this Experiment Station (240).

The spores of the covered smut, caused by *Ustilago hordei*, only adhere to the outer part of the grain, therefore, the grain can be disinfected by the formaldehyde treatment recommended for oats.

It has been thought that seed several years old might be free from the smut because of longer life of the seed than of the smut fungus. Zimmerman (303) found that it survives in the seed and produces smut for at least three years.

The scab, stripe and other similar diseases (see wheat) may affect the seed yield. They also may be seed carried (157, 193, 243). The bacterial blight of barley has been found to be seed borne, living dormant on the seed for at least two years (161). Treatment with formaldehyde one pint to 30 gallons of water for three hours at ordinary temperatures will help to reduce the diseases mentioned in this paragraph.

Rust has been reported within barley grains but it is doubtful if the disease is spread in this way (21).

Beans.

Several diseases of beans are carried by the seeds. The anthracnose, which causes the familar ulcer-like spots on the pods, goes through the pods into the young seeds. Seeds should be saved only from perfectly healthy pods and shelled by hand, or if this is not possible,

the seed should be hand picked, discarding all that are even slightly discolored (205). Disinfection is sometimes used, soaking the seeds one or two hours in ammoniacal copper carbonate (2 oz. copper carbonate and 1 pint of ammonia with water to make 13 quarts) (111). Anthracnose resistant varieties have recently been discovered (191). The bacterial blight may also go over on the seed and may be controlled by hand picking. For the rust, which is often destructive to our late bean crop, save seed from the most resistant plants (311). The mosaic disease is seed borne (337).

Some of the eggs of the bean weevils, so troublesome in stored beans in the South, are laid in the young pods. They may be controlled by fumigation of the ripe seed with carbon bisulfid or by keeping the seed beans in dry, air-slaked lime. See Bulletin 8, Maryland Extension Service (38, 65, 136, 139, 218, 315).

Beans harvested late are subject to injury by frost, at least the frost-killed plants will have beans in all stages of maturity.

In wet seasons, or on beans in contact with wet soil, there will be injury, or at least discoloration, from the action of the water and molds and other organisms. The harvested seed needs to be thoroughly dry before stored (159).

There is little danger of beans crossing, even if different kinds are grown close together.

Beet.

Black rot and other diseases (41) may be transmitted on the seed. Soaking the seed for 20 minutes in formaldehyde, one-fourth pint to six gallons of water, has been recommended as a treatment (111). After treating wash the seed, and either dry or plant at once. Formaldehyde has also been used as a seed treatment for the leaf spot (325).

Beets cross readily and have to be protected from the pollen of other varieties grown nearby, and carefully rogued for mixtures and variations in root color, etc. Some plants seed the first year, and if seed is saved from such plants this undesirable character may be perpetuated (159). Weather and other environmental factors and perhaps prematurely produced seed may increase this first year flowering (71). For other factors affecting seed production in sugar beets see Nos. 37, 208, 274, 332 in the list of publications at the end of this bulletin.

Buckwheat.

High temperature, wet weather, especially with hot sunshine after showers, drouth, or frost during the short season necessary for seed growth, are unfavorable to seed production (259).

Cabbage.

Cabbage is so subject to a number of serious diseases that may be carried on the seed (black-leg, yellows, black-rot) that seed disinfection is always advisable. The spores of the three diseases just men-

tioned may be destroyed on the seed surface by ten minutes disinfection with corrosive sublimate, one part to 1,000 parts of water, or fifteen to twenty minutes in formaldehyde one teaspoonful to a teacup of water; after treating wash in clear water and dry quickly (111, 114, 120, 122, 205).

Volga and Houser are rather resistant to the yellows disease, and still more resistant varieties have been selected at the Wisconsin and Maryland Experiment Stations (162, 297). It is said that the Hollander and the red and blue cabbages are less subject to the club-root.

The writers made a series of disinfections of cabbage seed in formaldehyde and corrosive sublimate, after which the seeds were germinated in sterile test tubes of synthetic agar. Some of the lots of seed proved to be free from fungous growth, but others developed fungi around the seed and the seedling made a growth inferior to that of seedlings from uninfected seed. It seems evident that fungi, parasitic or non-parasitic, may survive the treatment and interfere with the growth of the seedlings.

To secure some data on the use of hot water as a possible disinfectant for cabbage seed, two lots of cabbage seed were put in water at different temperatures for different lengths of time as shown in the following table. One hundred seeds were used for each temperature and time combination. One lot was 1914 and the other 1916 seed, both grown at this Experiment Station. Through the kind cooperation of Prof. C. P. Smith, the germination tests for this and other experiments were made at the State Seed Laboratory.

TABLE I.—PER CENT. OF GERMINATION OF CABBAGE SEED TREATED WITH HOT WATER.

Temperature in degrees Centigrade.	1914 Seed.				1916 Seed.			
	5 min.	10 min.	15 min.	20 min.	5 min.	10 min.	15 min.	20 min.
48	53	49	46	39	97	97	95	95
50	41	31	47	21	98	98	90	95
52	58	43	27	16	94	94	89	89
54	46	15	16	51	95	95	93	88
56	33	13	2	4	93	97	94	69
58	21	4	4	0	95	69	46	25
60	26	3	2	2	94	33	23	0

by treatment with formaldehyde, one teaspoonful to a cup of water, and then washed before planting or drying (205, 312).

Cucumber varieties and related plants, including vegetable peach, West India gherkin, snake cucumber, and pomegranate melon, intercross readily, and should be planted 40 rods or more apart to keep them from mixing. Cucumbers do not cross with watermelons, muskmelons, pumpkins, etc. (209).

In fermenting the seed out of the pulp, there is danger of the seed at the top discoloring, but apparently the vitality is not harmed by several weeks fermentation if they are stirred daily (159).

Eggplant.

Seed from rotten fruit is often injured and may carry the rot fungus; even the fermentation that is usually used to separate the seed from fleshy vegetables will at least darken eggplant seeds. The seeds start to sprout easily, and may loose vitality if not dried quickly after being taken from the fruit (159).

Flax.

The wilt and canker diseases are carried by the seed. Most of the diseased seeds can be blown out by fanning, as they are lighter; but the seed needs to be disinfected before planting, by spraying with formaldehyde, one pint to 40 gallons of water, using just enough to thoroughly cover the seed but not enough to start the mucilage to forming. Two quarts per bushel is enough. Sow before drying. Cutting when dry, and keeping the flax and seed dry will prevent much seed infection. Wilt resistant flax has been bred at the North Dakota Experiment Station. Uneven ripening is due to poor seedbed and varying cool weather near the time of maturity; the resulting mixture of immature seed, reduces the quality for oil. Seed is often injured by moisture during harvest and curing (29, 30, 34, 35, 149, 187).

Grape.

Many varieties are self-sterile, and some bear flowers of only one sex, and consequently require cross-pollination to produce seed (17, 151).

Several seedless varieties are in cultivation. Sultana and Sultanina are seedlings varieties commonly grown in California. The "dried currants" of the market are from a small seedless grape.

Lettuce.

No lettuce diseases are reported to be carried by the seed. Goldfinch and other birds sometimes eat a considerable percentage of the seed.

There is little danger in growing lettuce varieties close together for seed, as they do not cross readily.

Some varieties of lettuce are more susceptible to the influence of summer conditions, which induce them to shoot to seed rather than to form a head of leaves, and to reduce this tendency the earlier seeding plants have to be rogued from the seed rows. Warm, rainy weather may produce poor seed of low vitality (168).

Lima Bean.

The diaporthe pod spot invades, shrivels and darkens the seed, which may then carry the disease to the next generation. Clean seed should be used and they should be disinfected five to ten minutes in a water solution of corrosive sublimate, 1 to 1,000, or in formaldehyde, 1 to 100, or in copper sulfate, 1 to 100. They should be washed after treatment (121).

Lack of moisture in the air and low summer and fall temperature reduce the set of seed (245).

Muskmelons.

Muskmelon varieties cross readily with one another and may mix with the closely related vegetable peach and snake cucumber, but not with the common cucumber, watermelon, pumpkin, etc. (159, 209). In fermenting the seeds out of the pulp they may be injured if left in the ferment over three days. Blight resistant strains have been bred (25).

Oats.

The loose smut and also the anthracnose of oats is carried on the seed to the young plant. Several methods of disinfection have been used. The formaldehyde treatment is perhaps the best. Use one pint of the formaldehyde to 40 gallons of water and sprinkle this over the pile of seed oats while it is being shoveled over, until all the grains are thoroughly wet. The pile is then covered and let stand a few hours, after which the grain is sown or dried for later use. Care must be taken not to get the disinfected grain in contact with sacks, bins, machinery or anything that could reinfect it with smut spores; it is better to disinfect these also. Further details of this treatment are given in Bulletin 200 of this Experiment Station. Hot water at 132 to 133 degrees F. for ten minutes, or a three-fourths per cent. solution of liver of sulfur 24 hours, with frequent stirrings, have also been recommended (111, 240).

Sowing small seed, or seed grown under different climatic conditions, and cutting at full maturity or later decrease the yield of seed (43, 44, 166).

Seed formation in spring oats is prevented in Southeastern Maryland if there is hot humid weather at heading time (130, 240).

usually too low to make any preventive treatment profitable. A fusarium disease has recently been found to be carried on the seed (210). Several fungi attack the young ears and rot the grains, which are usually so thoroughly destroyed that there can be no danger of them transmitting the disease to the next crop, but corn from moldy cobs or with any discoloration on the grains should not be used for seed (8, 45).

There is no very severe insect injury directly connected with seed formation, except that the ear worm destroys a great deal of young grain (98). Varieties with long close shucks are much less injured by the worm. Such shucks are also a protection against the weevil which also attacks corn in the field (324, 345).

The young seed is easily injured by low temperature, and as frost often strikes the fields before the grain is mature, or at least before it is dry enough to withstand the cold, this is a common cause of low vitality in seed corn. The importance of well-dried seed corn protected from cold and moisture has been demonstrated again and again, and germination tests are often of great value in enabling the grower to pick out any injured ears. Corn is also more sensitive to high temperatures than other grains (50). Sweet corn dries more slowly than other varieties.

Corn should be allowed to fully mature on the stalk. Immature ears are more subject to rot, they give poor germination and do not have sufficient food for the young plant. The immature grains may start to grow again on the ear if moisture and temperature conditions are favorable (105, 116, 244).

Many investigations have been made to find whether grains from different parts of the ear, or from higher or lower ears on the stalk, vary in vitality or in the character of the offspring, and while some differences have been found, they are usually so slight, or even contradictory, that it may safely be concluded that they are accidental (46, 79, 101, 102, 103, 166, 171, 301). However, the variation in size and form of the butt and tip grains and the common injury at the tip from rot and worm makes it advisable to discard the end grains.

Walls, at this Experiment Station, found that the grains with the smaller germs make weaker plants less able to withstand drouth (285). There are various factors, some undetermined, that cause great variation in the vitality of different grains and ears, and while some can be controlled by proper selection, the only final safeguard is the germination test of individual ears before planting (148). According to Soule and Vanatta (253), large ears gave a higher yield and better vitality than small ears.

Hayward (133) found that removing the tassels from two-thirds of the corn rows did not increase the yield over the undisturbed third row.

In experiments made at this Station in 1891, and others since then, it was found that northern or southern grown seed corn did not do as well here as seed grown in this latitude (132, 254). Latitude makes no difference in the sugar content (262, 278).

The fact that corn crosses so easily, and the pollen is so abundant and so easily carried by the wind, makes the precautions relating to breeding of great importance, especially since unusual variations in the seed and the resulting plants have been discovered through the many recent investigations of corn heredity. These breeding problems cannot be gone into here, but full discussion may be found in the literature cited under the following numbers (58, 59, 80, 82, 83, 125, 126, 148, 160, 300). Among the more important dangers associated with pollination are deterioration from inbreeding (160, 320), and undesirable mixtures with other varieties. The latter may take place in fields a quarter mile apart, but may often be avoided by planting the different varieties so that they bloom at different times (254). See also sweet corn.

Cowpea.

There are no cowpea diseases known to be carried by the seed, but damp seeds are very liable to injury by molds. The Iron cowpea is resistant to the wilt disease, injurious in States south of Maryland.

The cowpea weevil lays its eggs in the young pods, and is controlled in the same way as the bean weevil (65, 142).

The considerable percentage of unripe seed on the plants at harvest, especially on late blooming varieties like the Unknown, is a common defect (132), and to get a cowpea that will mature more seed at one time is one of the main breeding problems (237).

We have made a preliminary investigation to find at how young an age immature cowpeas are able to germinate. Young pods from three days after blooming up to full growth were opened and placed at once in the germinator. It was found that half-grown peas would germinate, but the seedlings were slender and weak and made slow growth.

Winter Cress.

In open fields lightly infested with winter cress (*Barbarea verna*) it was noticed that in colonies of several hundred plants, around where a single plant had seeded the year before, the plants near the center were largest and bloomed first. Believing that this might be a good illustration of the effect of large and small seed, the seed of one plant was saved and sorted into several groups according to size and planted in the greenhouse. The seed in each group germinated well, but here another factor interfering with seed production appeared. Under greenhouse conditions the plants did not bloom in the spring but grew on all the next summer without a flower, some even producing a stem an inch or two long with the rosette of leaves at the top.

Cucumber.

The angular leaf spot and the anthracnose are both spread by infected seed. All cucumber seed should be disinfected before planting

by treatment with formaldehyde, one teaspoonful to a cup of water, and then washed before planting or drying (205, 312).

Cucumber varieties and related plants, including vegetable peach, West India gherkin, snake cucumber, and pomegranate melon, intercross readily, and should be planted 40 rods or more apart to keep them from mixing. Cucumbers do not cross with watermelons, muskmelons, pumpkins, etc. (209).

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Sowing small seed, or seed grown under different climatic conditions, and cutting at full maturity or later decrease the yield of seed (43, 44, 166).

Seed formation in spring oats is prevented in Southeastern Maryland if there is hot humid weather at heading time (130, 240).

Cheat, from seed sown with the oats, or on the ground already, sometimes takes the place of winter-killed oats, and has lead some people to believe that the oats had turned to cheat (240).

Oats are practically always self-pollinated (267).

Onion.

The smudge and smut diseases may be carried by the seed. These diseases have not yet caused trouble in Maryland, but where they are present it is best to disinfect for them by using formaldehyde, one pint to 30 gallons of water, sprinkling three or four quarts to the hundred foot of row on the seed after sowing and then covering at once. Ground quicklime, 75 to 125 bushels to the acre, stirred in the soil just before seeding has also been recommended (111, 281). It is preferable, if possible, to secure seed from disease-free fields. The neck rot disease is carried on the seed (329).

Too rich soil causes the blossoms to drop without making seed (159, 234). Moist air, before and after harvest, is very detrimental to onion seed vitality. Seed gathered when first black is immature. Just before they begin to shatter is the best time (20).

Pea.

The anthracnose disease, causing leaf and pod spots, may be carried by the seed. To prevent seed infection, spray just before blooming begins, and two weeks later, with 4-4-50 Bordeaux mixture; or better save seed from healthy pods only (111, 205). The fusarium stem and root disease also rots the seed (306).

Weevils lay eggs in the immature peas, and while their larvae do not always prevent the seed from growing, the weeviled peas usually make weak plants. For their control see bean (38, 65, 139, 142, 205, 218).

There is little danger of pea varieties mixing, as they, like most legumes, are nearly always self-pollinated; but they are so variable that varieties soon run out if the seed plants are not carefully selected (339, 343).

Frost injures the blossoms and young pods though the plants are quite resistant to low temperatures. The enclosed air in the pods is thought to have some influence on seed development, as the seed often does not develop in punctured pods (176.)

Peach.

Peach stones from trees with the yellows disease usually have the seed abortive and rarely germinate, but if they do grow they sometimes transmit the yellows to the young tree. Such seeds have been known, however, to grow into healthy trees (249). Seeds from otherwise prematurely ripened peaches are low in vitality (286). To avoid

the yellows, nurserymen use seed from regions supposed to be free from yellows, but the "natural" seed from North Caroline, Tennessee, Arkansas and Kansas cannot be depended on as the yellows or the similar rosette disease is frequent in these States.

The split-pit disease injures the seed or admits fungi that cause it to decay.

Winter injury to the buds at temperatures below 15 degrees F., or at much higher temperatures, if growth has started, is a common source of fruit failure. The seed in young fruits may be killed without injury to the surrounding parts (47).

No peach varieties are known to be self-sterile.

PEANUT.

The leaf-spot spores occur on the seeds, but seed treatment has not proved effective (299). *Sclerotium rolfsii* and other fungi cause decay of the seeds in the soil. Rodents and various insects destroy the forming seeds and causes not fully known prevent seed formation in many of the shells. It is not necessary to cover the blossoms with soil, as the young nut finds its own way into the ground, unless it is very hard (19).

PEAR.

The difficulties in seed production are about the same as for apple (12, 86). Cold weather at blossom time, thrip, midge, psylla and other insect injuries, etc., often cause most of the blossoms to fall without setting fruit (64, 211). The almost exclusively Keiffer orchards in Maryland sometimes loose their flowers through lack of cross-pollination, as this variety is usually self-sterile, as are many other, but not all pear varieties.

PECAN.

A fungus (*Coniothyrium*) causes a spot on the kernels and the apple bitter-rot fungus produce an anthracnose of the nuts (222, 340).

A weevil deposits its eggs in the immature nuts, which are later injured by the larvae. Chittenden suggests carbon bisulfid fumigation and destruction of the fallen nuts by hogs or poultry working under the trees (49).

Some varieties produce their pollen after the pistillate flowers have passed the receptive stage and require cross-pollination (152, 266, 317).

Southern varieties start into growth too soon when planted in the North and the fruit buds get killed by frost (152).

Grafting on hickory greatly reduces the size of the nuts. Growing in a high altitude also makes small nuts. The nuts are shorter in dry seasons (265, 266).

Plum.

Many of the conditions that interfere with seed development in the peach affect plums also. The plum-pocket disease, due to a fungus which attacks the flowers, changes the young fruit into a seedless bladdery structure. It is not common on cultivated varieties.

All the native and most of the Japanese varieties are self-sterile. Pollination of these may be secured by planting them near other varieties that bloom at the same time (145, 287).

Popcorn.

Accidental crossing with other kinds of corn is the chief difficulty. Planting within ten to twenty rods of field corn is likely to ruin both kinds for seed and to injure the popping quality.

Popcorn should be fully ripened before storing and before frost to insure good popping quality (127). See also corn.

Potato.

Like many plants propagated chiefly by other organs than seeds, many varieties of potato bloom sparingly or not at all. McCormick is the only one that makes much seed in the South, but varieties that make no seed here may do so in cooler regions. Even when flowers are produced on some varieties they drop very soon or produce no viable pollen (263).

Pumpkin.

Pumpkins will cross with any varieties of squash or gourd belonging to the same species, but not with those of the other common squash species. They will not mix with watermelon, cucumber or muskmelon (209). Seed should be saved without fermentation if discoloration is to be avoided (159).

Quince.

The rust which grows on the trunks of cedar trees is very destructive to quince fruits when it attacks them. Blight, black rot and other factors not determined reduce the set of fruit to an unprofitable degree on most Maryland quince trees.

Rye.

A smut occurs occasionally on rye and is carried on the seed. The anthracnose is also seed carried, and treatment with formaldehyde as recommended for oats and wheat will partially control it (111, 174, 243, 255). Dry heat of 150 degrees F. has recently been used in Europe for disinfecting rye for an internal fusarium (193, 336).

Ergot is a fungous disease which transforms the grains of rye and various grasses into dark purplish, elongated bodies, which carry the fungus over to the next season. It is quite poisonous to animals. Ergot is very rare on rye in Maryland, but is more common on grasses. The larger ergot bodies can be blown out in fanning, and the remainder as well as the lighter grain can be removed by putting the grain into salt brine strong enough (about 20 per cent.) to float them off while the heavier grain sinks. The grain must then be washed to keep the salt from injuring the seed (158).

Rye is self-sterile, but as the pollen is carried some distance by the wind isolated plants often produce a few seeds.

Sorghum.

The kernel smut, which destroys the separate seeds, and the head smut which destroys whole heads are both transmitted by the seed. The latter is not controlled by seed treatment, but seed can be disinfected for the kernel smut by 15 minutes to one hour in formaldehyde at the rate of one pint to 30 gallons of water, after which it should be dried. Avoid seed from infected fields (111, 219). A fusarium disease of sorghum is also seed borne (210, 344).

Seed formation is often prevented by a midge which lays its eggs in the young flowers. The work of this insect, sometimes known as blast, sometimes results in a practical failure of the seed crop. It is not so bad in dryer regions (60). Birds eat a great deal of the maturing grain.

The various sorghums cross-pollinate freely, and pure seed cannot easily be obtained from plants grown near kafir, broom corn, Sudan grass or other sorghums (182). The sorghums are self-fertile.

In the North the season is often too short to mature seed of the sweet sorghums. The harvested heads must be carefully cured to prevent heating (74).

Soybean.

Some varieties have too long a season to mature seed in Maryland, though frost that will completely kill corn will not prevent soybeans from maturing if the seed are formed but not yet hardened. In Bulletin 201 of this Experiment Station, Schmitz gives the time of maturity of different varieties (190, 241). Hayward (129), at this Station in 1889, found that soybeans less than a third the size of the seed planted, and apparently immature from early frost, germinated perfectly in the seed tester. The seed must be dried thoroughly after threshing to avoid heating and molding.

There are no common diseases affecting the seed.

Spinach.

There is some indication that the mildew is transmitted on the seed (169). There is danger of the varieties crossing unless grown 100

feet or more apart. In contrast to many plants, the richest soil is best for seed growing. If the seeds are fermented out there is some danger of discoloring those of the winter variety (159).

Squash.

The many forms of squash belong to two species. Those with the thick, round stem to the fruit are the typical squashes. Those with the small angular stem, broadening out where it is attached to the fruit, include the true pumpkins, though some of the other kind are of pumpkin form and are so called. The two kinds do not inter-cross, but the varieties of either will mix readily with other varieties of the same species. The squashes and pumpkins do not mix with melons, cucumbers, etc., even when grown close together (209).

Lack of cross-pollination is probably the cause of many flowers, especially the earlier ones, failing to set fruit. They can be easily pollinated by hand.

Sudan Grass.

The seeds are sometimes destroyed by the kernel smut. They can be treated for this with formaldehyde as recommended for sorghum (271).

There is some danger of crossing with other sorghums. Any chance for mixture or crossing with Johnson grass should especially be avoided.

The grass should be cut for seed when the first heads are overripe in order to reduce the number of immature seeds harvested to a minimum (238).

Sweet Clover.

Due to the considerable variation in the time the different blossoms appear, it is not possible to get all the seed ripe at once, without losing the earlier pods. The best time to cut is when about three-fourths of the pods have turned dark. Shade due to too thick stand or any other cause reduces the seed yield. Fungous diseases probably interfere some with seed production (56).

Sweet Corn.

In addition to the troubles mentioned under corn, sweet corn is subject to a bacterial disease that may be carried on the seed. Avoiding seed from diseased plants, and probably seed treatment, will help to control it (256). Some varieties are more subject to smut than field corn. Bulletin 204 gives the difference in varieties at this Experiment Station, with reference to smut and drouth injury (297).

Bulletins 96 and 120 of this Station give the following points regarding sweet corn seed production, on which investigations were begun here in 1903. Sweet corn is especially subject to injury by cold,

and although there is no sign of deterioration in the grain, germination may show a greatly reduced vitality. Sweet corn, cut and shocked like field corn, is in danger of souring and molding unless the weather is cool and dry. Hot damp weather will discolor the grain if left to ripen on the stalk until the husk opens, but if the ears are husked and exposed to the sun for a few hours fermentation will be prevented (254). No difference was found in the sugar content of the upper and lower ears. The sugar content was increased by breeding. Stowell's Evergreen was much less injured by the ear worm than Crosby (262, 278). Varieties like Country Gentleman with irregularly arranged kernels are less injured by the worm (345). See corn.

Timothy.

The leaf smut is carried by the seed, and while this disease is not common in Maryland, the seed usually contains some of it. Putting the seed in water at a temperature of 126 degrees F. for 15 minutes, after soaking in cold water for five or six hours, is recommended to control the smut without injuring the seed. Chemical treatment is less effective (206).

There are marked difference in rust resistance in the different timothy varieties (see 289, where also other hereditary characters are discussed).

Tobacco.

The mosaic disease seriously injures the blossoms and causes small abnormal seed pods. In case seed is produced by the diseased plants, it may be weakened but does not carry the disease to its offspring (2). No other diseases are known to affect the seed directly, but there is good opportunity to select strains resistant to various diseases (157).

While the increased vigor of plants from large seed is important in most crops, it is more so with small seeded plants such as tobacco. The light seeds make inferior plants. They can be separated out by any simple winnowing device, or by settling in a glass of water, the heavier seeds going to the bottom first (185, 258, 275).

The flowers are easily cross-pollinated by the moths of the tobacco worm and other insects, but flowers can be bagged and allowed to pollinate themselves, as they are self-fertile, and can be thus inbred without deterioration (155). Premature pollination may injure the flowers (124). Allowing the lateral branches to form seed hinders the best development of seed on the central stalk (213).

The Maryland Experiment Station began tobacco breeding in 1904 (215), and in Bulletins 103 and 188 the following additional results relating to seed production are reported. Seed raised under bags as mentioned above, made larger and better plants and a more vigorous crop. The Maryland Mammoth variety, originated here, does not

reach the flowering stage under ordinary field conditions. It can sometimes be flowered earlier by dwarfing the plants in pots with a reduced amount of soil but with plenty of sunlight and just enough water to grow and mature the seed. Seed from these dwarfed plants produce full-sized plants in the field. With this variety it is especially necessary to prevent crossing, as the Mammoth character disappears in the plants grown from its seed if crossed with other kinds (55, 100).

Tomato.

The fusarium wilt disease is to some extent carried by the seed (53, 200). On farms not yet infected with this wilt, avoiding seed from infected plants will help to keep it out. On infected farms, the wilt resistant selections described in our Bulletin 180, and now being disseminated in the State, can be used (200). Bonny Best seems to be resistant to the blossom end rot (205, 264). Stone and Sterling Castle are more or less resistant to the leaf mold, which is one of the worst greenhouse diseases. There is great variation in different varieties and in different plants within the variety, in the amount of infection by the leaf blight septoria, at least in the seedling stage, and it is probable that a leaf blight resistant tomato may be secured. Winter blight may be carried by the seed (331).

Seed from rotten tomatoes is often dark and may be injured by the rot organisms. To determine the effect of the rotting on seed vitality, we saved 8 lots of seed from badly rotten tomatoes in October. Germination tests were made, and gave the following percentages: 29, 76, 93, 88, 98, 99, 97, and 92 and an average of 84. The check from normal fruit saved in the usual way gave 98 per cent. germination. The danger of getting seed infected by some of the rot organisms that might be transmitted to the offspring, is another reason for discarding such fruit when saving seed.

Another germination test of seed from rotted fruits, was made from seed of fruits on vines of Stone tomato which were pulled when the fruits were not more than one and a half inches in diameter and entirely green. The vines were hung in the laboratory and the fruits allowed to ripen and partly decay, after which the seed were washed out and the germination test made. Sound fruits of this lot gave 84 per cent. germination; two-thirds rotten, 98 per cent.; half rotten, 87 per cent., one-third rotten, 99 per cent.; and seed from normally ripened fruit, used as a check, germinated 98 per cent. Considering the rot and the immaturity of the fruit when the vines were taken from the field, the vitality is very good.

The corn ear worm is the only insect that causes much injury to fruit or seed, and this chiefly from rot organisms entering through the wound.

Tomatoes are self-fertile and usually do not cross much. When two varieties are grown close together, one to five per cent. of the re-

sulting seed may be crossed, but the per cent. is usually less. In selecting seed plants in the field one is more likely to pick the hybrids as they are usually larger and more productive. The next generation will show some breaking up of the hybrid and less vigor in some of the plants, but they will probably yield better than the parents of the cross. All varieties do not give an improved yield from crossing, but in some the increase is more than ten per cent., which will far outweight the slight trouble of making the crosses. The fruits of the hybrid plants are a little larger, and usually much more vigorous and productive, and they sometimes ripen earlier than the earlier parent (89, 160, 179, 200, 292).

In order to get the best advantage from the increased yield of hybrid tomatoes, it is best to select two varieties, both of desirable type, and hand-pollinate the blossoms of one as they open, with pollen from the other, and save seed from the resulting fruits. To do the work thoroughly, the anthers must be taken out of the flowers that are to be pollinated, a day or two before they open, so as to prevent the usual self-pollination; but sufficient success to make the work profitable should be obtained, by taking pollen from one variety, by gently tapping the flowers about eight to ten o'clock on a clear day, and allowing the pollen to fall on the thumb nail and then applying this to the tip of the freshly opened flowers of the other variety.

The pollen is shed in the morning on warm sunny days. Rainy or even cloudy weather interferes with pollination and the blossoms fall without setting fruit. Cold weather; hot, dry weather; too much water in the soil; an over supply of nitrogen, and probably other conditions not yet fully determined, cause the blossoms to drop without making fruit (168, 233, 227).

As recorded in Bulletin 127 of this Experiment Station, greenhouse tomatoes have to be hand-pollinated in order to set fruit, but it was found that Dwarf Aristocrat and a few others would pollinate themselves (54). Injury to the blossoms, from pollen applied too soon has been noted (124).

The time of blooming may be somewhat delayed by over fertility of the soil. On plots of tomato where excess of different fertilizers was being tested we found the differences in Table II and the position of the first flowers shown in the following table:

The general tendency of phosphorus fertilizers is to cause earlier maturity in other ways as well as in earlier flowering.

White found (see Bul. 173, Md. Exper. Station) that hereditary differences, persisting at least three years, developed in tomatoes grown several years on excess of different fertilizers, especially on the strong dried blood cultures. Marked differences were noted in the size and color of the seedlings from seed grown on different fertilizers. In one case plants from seed grown on excess of dried blood, produced eight per cent. of plants with a tendency to leaf-like development in the abnormal flowers. Plants grown on normal soil, from

TABLE II.—BLOOMING OF TOMATOES ON EXCESS OF DIFFERENT FERTILIZERS.

Treatment: Excess of—	No. of Plants in Plot.	Date of First Bloom.	Average No. of Leaves Below First Bloom.
Complete fertilizer	20	Nov. 18	11.15
Dried blood	23	Dec. 14	11.35
Dissolved rock	27	Dec. 3	11.04
Raw rock	23	Dec. 17	11.57
Muriate of potash	20	Dec. 19	10.08
Nothing	16	Dec. 23	11.75

seed produced by plants on excess of phosphorus or of potash, were light green and from dried blood, were dark green (296).

Tomatoes will set fruit without seed, but such fruits are always very small. A few seeds will greatly increase the size. Some interesting results on the relation of seed to size of fruit were obtained at the Maryland Experiment Station by Bishop in 1890. An examination of 627 fruits or 64 varieties of tomato showed that the largest fruits had the largest seeds and the smallest number of seeds per weight of fruit, while the smallest fruits had the smallest seeds and the largest number of seeds per weight of fruit. Early varieties were large seed producers (22, 89).

A number of experiments have shown that immature tomato seeds will germinate, but while the resulting plants ripen their fruit earlier, the plants are weak and less fruitful (7, 63, 269).

We have found that the seed from entirely green but almost full grown tomatoes will germinate, but the greener the fruit the longer it takes them to germinate.

The following tests on tomato seed ripened in the field after the first killing frost were begun October 16, 1917. Seed was saved from the field on each of the dates given in Table III, and after December 1, germination tests of all were made in the State Seed Laboratory, with the results shown in the table.

Nine frosts occurred during October and twenty during November, but until after October 27, the vitality was not lowered much, but fell slowly after that. There would rarely be occasion to make use of such frost ripened seeds, but there is nothing to show that they are not mature and normal for a long time after the vines are killed.

In saving tomato seeds, the fruits are crushed or the seeds squeezed out, and the pulp or juice containing them is allowed to ferment a few days to clean the seed. It is necessary to stir the mass every day to keep the mold that forms on the top from darkening the seed (159). In warm weather 24 to 48 hours is sufficient fermentation, but several days will not hurt them.

TABLE III.—GERMINATION OF TOMATO SEED TAKEN FROM THE FIELD AFTER FROST.

Date of Picking.		No. Days After Frost.	Per Cent. of Germination.
October	16	0	96
"	18	2	97
"	20	4	96
"	22	6	97
"	24	8	92.5
"	27	11	98.5
"	30	14	89.5
November	2	17	86
"	6	21	97.5
"	9	24	96.5
"	13	28	83.5
"	19	34	78
"	21	36	96
December	1	45	64.5

Table IV shows the results of some experiments that we have made to determine the effect of this fermentation on seed vitality. The pulp from a bushel of normal, ripe tomatoes was mixed and one-fourth pint in each of ten tumblers was placed in an incubator and kept at 29 to 30 degrees C. The tumblers were removed as shown in the table, and at the completion of the test 200 seeds of each were given the standard germination test in the State Seed Laboratory. At this temperature, five days fermentation did not affect the vitality, but after that a rapid drop in germinating power will be seen. It may be that this loss was due to the seed germinating in the fermenting juice, as some sprouted seed was noticed when the seed was being taken from the tumblers longest in the incubator. We find that the seed may be injured by germination starting when the cleaned seed are being dried if they do not become dry in two or three days. However, seed from which the embryo was already protruding as much as one millimeter, and were then dried, showed no loss of vitality in a germination test.

In the case of the unfermented sample, the seed was taken from the fruit and dried at once. The first sample with one day's fermentation was fermented under room conditions outside the incubator.

We have found that tomato seed was sometimes badly blackened by drying on a copper screen, but a germination test showed that this did not affect the vitality.

TABLE IV.—GERMINATION OF TOMATO SEED FERMENTED DIFFERENT LENGTHS OF TIME.

No. of days fermented..	0	1	1	2	5	8	12	17	23	31	39
Per cent. of germination.	92.5	95	91	94	97	38.5	23.5	0	1.5	1	0

WALNUT.

The Persian (English) walnut blight, common in California, and recently located in the East, attacks the young nuts and causes them to fall at any time after they are one-eighth to one-half inch in diameter. In California, late blooming trees often escape the blight, due to dryer climate at the time they are in flower. The blight may attack other walnut species, including the common black walnut. Other conditions that may make the young nut drop are, curculio, poor pollination and cold weather at blooming time. Unless the male catkins are present with the female and in bloom at the same time, there will be no set of nuts. Young trees are especially subject to this trouble.

Hot weather may cause a browning of the nut meats, as well as other injury to the nuts. The nut meats may be shrivelled from poor pollination, lack of soil moisture, attack of aphids, etc. (39, 181, 252).

Whether the molds that often destroy the walnut meats, enter before the seed is mature, has not been investigated.

WATERMELON.

A number of diseases attack the fruit, but none injure the seed directly. Except the wilt, a common southern disease, now beginning to appear in southeastern Maryland, the fruit diseases are not carried by the seed to any great extent. Formaldehyde, one-half per cent. solution in water for 30 minutes, has been used to disinfect watermelon seeds for this disease (92). Good wilt resistant varieties have been bred by the U. S. Department of Agriculture but they are not of commercial type (204, 205).

Watermelon varieties will cross with one another and with citrons but there is no danger of mixing with pumpkins and other cucurbits. The flavor sometimes supposed to come from growing near pumpkins must be due to some other cause (209).

WHEAT.

Two smuts attack wheat and destroy a varying percentage of the grain. The loose smut is the most common and widely distributed. It causes the affected plants to mature their heads before the healthy ones, and converts nearly the whole head into a black dust about the

time the normal heads are blooming. The smut spores pass to the flowers and begin their growth again in the outer parts of the young grain, and although the infected grain is not noticeably injured, the live smut plant is thus carried over and causes the destruction of all the grain that grows from such infected seeds. Chemical treatment is not very affective for this smut, on account of the internal infection.

The best method of treatment for the loose smut is to use the hot water treatment on enough seed to sow a seed plot large enough to supply seed wheat for the following year. Sow this seed plot as far as possible from other wheat to prevent reinfecting it from the smut which may carry a long way on the wind. Briefly, the hot water treatment is as follows: Soak the seed five to seven hours in cold water, then dip it in a tub of water at 129 to 130 degrees F. for a minute or two, then into a second tub of water at the same temperature for ten minutes. The temperature must be kept as near as possible to the given degree; if allowed to go above 132 it will injure the grain, and below 124 it is not effective against the smut. The grain should be agitated while in the water. Full details of the treatment are given in Bulletin 198 of this Experiment Station (236, 239).

The stinking smut affects the separate grains, filling them with a stinking black mass. The spores from the broken smutted grains become attached to the surface of the sound grains and infect the young wheat when it starts to grow. Being on the outside, the smut is easily killed on the seed grain by the formaldehyde treatment recommended for oats and described on page 89 of Bulletin 198 of this Experiment Station (173, 239, 314).

The scab fungi, which attack and shrivel the heads and young grains in hot damp weather before harvest, and cause the common moldy or pinkish chaff, sometimes reduce the yield as much as one-half. Scab is also carried by the seed. The formaldehyde treatment is of some benefit in controlling them. The velvet-chaff wheats are the worst affected, and smooth varieties seem to scab more than the bearded (239, 272). Most of the scabby grain can be fanned or sieved out, and only the larger, healthier grain sown (111).

The anthracnose, which is a destructive parasite of young wheat, is also carried on the seed. It may be partially controlled by the formaldehyde treatment for stinking smut (111). Black pointed, purplish, white spotted, bleached and blistered grains may result from the attacks of this and similar fungous diseases (32, 243).

European writers have recently reported cases of poisoning from the effect of internal infection of wheat and other grains by fusarium. They recommend dry heat of 140 degrees F. for 24 hours for disinfecting wheat, oats and barley, external chemical disinfection not being found effective (193, 336).

Wheat rust is sometimes carried in the seed, but there is very little evidence that this is a menace to the succeeding crop. The great reductions in grain yields due to rust is mostly from its injury to the

stem and leaves (21, 115, 318). Rust resistant varieties are being found (327).

A new bacterial disease of wheat, which injures the grain and may be transmitted by it, has recently been found in the Middle West (250).

Other directions for seed wheat disease control may be found in publications 28, 32, 33, cited in the bibliography at the end of this bulletin.

The Angumois grain moth infests the young wheat grains even before ripe, and destroys a great deal of grain in the fields as well as in the bin. Any means that will prevent the moths leaving infested bins, etc., will aid in keeping it out of the field (322).

Investigations in Colorado indicate that the yellow berry trouble is due to lack of nitrogen in the soil or to too much potash for the nitrogen present (134, 313).

Wheat very rarely crosses, and varieties may be grown side by side without mixing, so without artificial crossing there is not much chance of improving wheat by selection (347). Six years effort in that line at this Experiment Station was with without success (237).

Hayward found no benefit on the Maryland Experiment Station farm from obtaining seed wheat from distant localities in the same latitude (94, 131, 156, 212).

The failure of some of the flowers in a wheat head to produce grain is dependent on crowding of the plants in the field, early seeding, too great a proportion of nitrogen in the fertilizer, and various hereditary characters, as well as the diseases before mentioned (110). The grains from the base and apex of the head are usually lighter and slower in germination (107, 224). The quality of the grain is dependent on many things, some of which are under the control of the grower (177).

If wheat is cut before the grains have begun to harden, the grains will shrivel. Such immature grain is lessened in value for seed (27). If allowed to stand till fully ripe bleaching and shattering may occur (88, 173). The grains with the greatest density, rather than the largest grains, grow best, though these two characters usually go together (131, 154, 166).

In northern wheat regions, frost injury before the grain is ripe, sometimes occurs, and changes the chemical composition of the grain as well as lowers the vitality (27, 115, 247, 338).

NOTES ON MINOR CROPS.

Alder. Seed production is not very abundant, and some of the seed is dstroyed by a fungus (*Taphrina*) deforming the fruit much like its relative which produces plum pockets.

Almond. Because of the early flowering habit, seed and consequently fruit, often fails from injury by late frosts, but much of the failure is no doubt due to the self-sterility of many of the varieties and no opportunity for cross-pollination.

Apricots also often fail to set fruit for the same reason as almonds do. They are subject to the usual stone fruit troubles as well. See peach.

Aster. The yellows disease reduces seed production very much, but the seed do not transmit the disease (251).

Banana. Seeds are extremely rare in the common cultivated varieties (5).

Beech. Seed very rarely develops in the beech nuts in Eastern Maryland.

Bermuda grass rarely seeds this far north, but is spread readily by the running rootstocks. The best seed is produced in hot dry climates (276).

Blackberry. The different varieties differ in self-sterility and in disease resistance (77, and Md. Rept. 3).

Bluegrass. The cause of much of the low vitality of bluegrass seed is due to harvesting immature seed. The heating of these in curing without access to air causes further loss. Seeds allowed to heat to 140 degrees F., even for a short time, are worthless; 122 is as high as the temperature should be allowed to go (99).

Broad bean. This bean, so productive in Europe, rarely sets seed here, apparently on account of the hot dry summers. It might be a profitable crop in the mountain counties (315).

Broom corn. The kernel smut is carried on the seed, which can be disinfected by soaking in sacks for one hour, in formaldehyde, one pint to thirty gallons of water, or by sprinkling with the same, as for oat smut. Broom corn crosses easily with all sorghum relatives, and the hybrids may be worthless for broom purposes. The seed from plants properly harvested for brooms is too immature for planting (230).

Canada bluegrass. (202).

Canteloupe, see muskmelon.

Castor beans hybridize as readily as corn , and the seeds of varieties grown close together are almost certain to be crossed. Late maturing varieties are subject to frost injury, and the pods do not open properly if the plants are killed before the seeds are mature. The seeds are matured over a long season, and while some pods are ripe and have exploded and thrown the seeds away, there are others in all stages of development on the same plant.

Catalpa is often planted for a rapidly growing, durable wood. Many plantings have failed because seed of the wrong species was used. *Catalpa speciosa* is the only one that is desirable. The different species hybridize readily through the action of bees or other insects, and seed trees should be a mile or two from other kinds of catalpa (242).

Cedar, Red. The seeds have a long dormant period. One should not expect to get all the good seed to germinate, even in a year.

Century plants do not flower and seed until the plants are a num- of years old, and then die after ripening seed. They will not pollinate themselves.

Chard. See beet.

Cherries are subject to much the same injuries as other stone fruits.

Chickpea. High humidity at flowering time causes a great reduction in the set of seed (147).

Chicory varies much in the hereditary characters of root, seed, self-sterility, etc. (165, 261).

Chinese cabbage seeds the same year if sown in the spring, but will make heads if sown in mid-summer. In the many varieties and species related to the cabbages and mustards there are all gradations between annuals and biennials, and the tendency to flower the first or the second year can be more or less varied by differet times of planting and by checks due to drouth, cold, etc.

Citrons will cross with watermelons but not with the other commonly cultivated cucurbits.

Citrus fruits. Seedless varieties are well known. We have seen several cases of seeds germinating within sound fruit. Each seed usually contains several embryos, and a number of trees of different character may grow from one seed (341). The seed easily lose their ability to germinate if dried.

Corn salad ripens seed over a long period, so that some immature seed will be harvested.

Cotton anthracnose, carried in the seed can be controlled by seed selection, the same as with beans, and also by means of resistant varieties. The bacterial blight is probably carried by the seed (14, 104, 138, 228). Wilt and other defects can be controlled by resistant varieties (203). The boll worm and especially the boll weevil and pink boll worm, destroy a very large amount of seeds as well as of cotton. The weevil is carried in the seed (150).

Crocus seeds are produced just at or below the surface of the ground, and might easily be overlooked.

Dahlia. In order to get better flowers, dahlias are usually planted too late to make good seed, as most of the heads are injured by frost before the seed is mature. Seed partly ripened can be brought to maturity by cutting and keeping in a dry place with the stems in water until the heads dry up. Dahlias very rarely breed true to seed.

Dates do not set fruit nor produce seed unless pollinated from the male date trees. Artificial pollination has been practiced since prehistoric times in order to insure the yield of fruit (268).

Dewberry. Some varieties are self-sterile. Lucretia is not (77).

Emmer. The seed problems are about the same as for wheat.

Ferns. The fact that we have several times received specimens of ferns in which the fruit dots on the lower surface of the leaves had been mistaken for disease spots, is excuse for stating here that the rough, thick, brownish dots or stripes on the back of the fern leaves contain the spores by which the ferns are reproduced, and take the place of seeds in the higher plants.

Fescue. Rust and pasturing in spring and fall reduce the seed yield. Bleaching and discoloring of the seed by weather is prevented by stacking (282).

Feterita is not attacked by the smuts that destroy the grain in other sorghums (135).

Figs furnish one of the most interesting cases of failure to produce seed without cross-pollination. The story of the minute insect by which it is accomplished and the practice of caprification can be only mentioned here (81, 220).

Fir. In the balsam fir, crowding reduces seed production, light favors it. Firs usually produce a good crop of seed only at intervals of several years (91, 194, 304).

Ginkgo. Single pistillate trees may bear no fruit, because there are no staminate ones near enough to pollinate them.

Ginseng. The alternaria blight attacks the seed heads, causing the berries to drop. No ginseng diseases are known to be seed carried (294).

Gourds are not known to cross with other species of cucurbits, but will mix with varieties of the same species, including some of the squashes and pumpkins, if the gourds are of that type.

Grasses. The seeds of many grasses are destroyed or replaced by the fungi that cause smuts and ergot. The smut mentioned under timothy is common on many grasses (308, 310, 318).

Hazelnut. Weevils lay eggs in the young nuts which are later destroyed by their larvae (39, 49). Winter injury and late frosts are common causes of nut failure.

Hemp seeds are borne on separate plants from the pollen, but as both kinds are nearly always present there is rarely any lack of pollination.

Holly. Some trees fruit much younger than others, and some bear berries much more abundantly than others. If the time comes when our wild holly is exhausted by the Christmas green trade, there is ample opportunity to select full berried strains of holly for cultivation. Shade tends to prevent the formation of berries.

Hollyhock. The rust, which is destructive to all parts of the plant, may be carried in the seed (24).

Horseradish produces seed very rarely.

Iris. The cultivated varieties of iris usually do not produce seed without artificial pollination. The stigmatic surface is at the upper end of the petal-like styles, and would probable be overlooked by the uninitiated.

Japan clover does not seed well in Maryland, except in long seasons. The seed shatters easily (132).

Kafir. Home-grown seed is usually superior to imported. Seed selections are best made in the field before hard frost. The varieties cross readily with one another and with other sorghums, and seed selections should be made at least 300 feet from other kinds. The

sorghum kernel smut may attack the seeds; for treatment for it, see sorghum (135).

Kale and Kohl-rabi. See cabbage and 260.

Legumes. A great many legumes are self-pollinated. Most of them produce a variable percentage of "hard seeds" which germinate with difficulty (310).

Lily. Some species do not set seed without hand-pollination. Lily seeds often take a year or two to germinate, but sometimes the fresh seed before it has hardened will start quicker (330, 346).

Mangel. See beet.

Mango seeds have more than one embryo, and one seed may make several seedlings (183). Recent studies of pollination difficulties have been made (335).

Medick. The chief difficulties in seed production by the cultivated species of medicago, or bur clovers, are: uneven ripening, a tendency for the pods to drop as soon as ripe, germinating in the burs in rainy weather, and the ravages of the clover seed chalcid. They are self-fertile (180).

Millet (see also Proso). The common foxtail type of millet is sometimes attacked by a smut which destroys the seed (146). Dipping for ten minutes in formaldehyde, one pint to 30 gallons of water, draining and leaving in piles for two hours, and then drying, is the most favored treatment (283).

Milo may be resistant to the sorghum smuts (135). The undesirable recurving of the heads seems to be partly a hereditary character, but influenced by climatic conditions (61). The sorghum midge sometimes prevents seed production.

Oak. Weevils and different kinds of gall insects interfere with the production of acorns (39). The white oaks mature their acorns the same year they bloom, the black oaks, the second year. The seed from young white oaks does not produce as strong vigorous trees as from older ones. Old trees have smaller acorns.

Okra varieties cross readily and if they are brought to seed close together they would have to be bagged and hand-pollinated to prevent mixing (18). The corn ear worm destroys some seed.

Orchard grass. Inferior seed as a result of cutting too soon, can be recognized by its light green color; it should be straw colored (201).

Orchids produce no seed unless the flowers are carefully pollinated. The process of accomplishing this is wonderfully varied and often complicated in some of the many different genera. The seeds are extremely small and appear to be abortive. The failure of the seeds to produce plants is often due to the absence of the symbiotic fungus that must be present before development will take place (346).

Papaya. See 141.

Parsley varieties cross readily.

Parsnip crosses with either wild or cultivated parsnips.

Peonies usually do not seed here without hand-pollination.

Pepper, Red or *Cayenne.* The seed is easily darkened by fermenting the seed out of the pulp (159).

Persimmon. Seedless varieties are in cultivation. Pistillate and staminate flowers occur on the same tree or on separate ones.

Petunia. The commonly grown varieties are hybrids and soon break up, if unselected seed is used. The very double kinds are produced from seed of the semi-double, only a part of which produces double-flowered plants (346).

Pine seeds ripen the second or third season after blooming. Rust sometimes attacks the cones (291).

Pineapple. The cultivated forms rarely produce seed.

Poinsettia. Seed does not set on the flowers of this plant as commonly grown, possibly due to lack of cross-pollination.

Pomegranate. There are all stages of sterility in the flowers, and all but the perfect long-styled ones drop without making fruit. A rot sometimes destroys the inside of the fruit, starting in the blossom (144).

Proso. A smut sometimes destroys the grain, and is carried over on the seed (146).

Radish varieties cross readily with one another and with the wild radish which is occasionally found in grass fields in Maryland. The white rust sometimes destroys the pods.

Rape. See cabbage and (170).

Raspberry. There is no danger from self-sterility. Anthracnose often attacks and destroys the fruit.

Red gum. Most of the seed is abortive (48).

Rice. Rains at blooming time prevent pollination. Mixing or crossing with the undesirable red rice is often a difficulty. Cutting after the rice is fully ripe makes it harder to hull and poorer in flavor (196). Several diseases, including a smut, attack the grains (137), for treatment for these, see 4 and 186.

Rutabaga. See cabbage.

Rye grass. These grasses sometimes contain the seed fungus to which is attributed the poisonous character of the darnel grass which belongs to the same genus. Freeman has shown the possibility of selecting out races of these grasses (Lolium) free from the seed fungus (90).

Salisfy seeds the second year; its varieties cross easily.

Salt-bush seeds are easily overheated, blackened in the sun or spoiled by dews (246).

Sapium. Seeds of sapium and other tropical trees of the spurge family, often contain the larvae of insects, which cause them to spring about in a mysterious manner. They are the so-called "jumping beans."

Shallu heads are likely to be damaged by the midge more than other kinds of sorghum, because of its late maturity. Frost may injure the seed for the same reason (231).

Spruce seed is produced more abundantly at intervals of a few years. It is often poor in vitality. See publications of U. S. Forest Service.

Stock. The important problem in seed production is to select the seed from the proper plants to give the largest percentage of double flowered plants in the offspring, as the double-flowered ones do not make seed. Strains that will produce more double flowers can be selected out. The stock seed experts make their selections from pod characters (346).

Strawberry. Lack of pollination, especially in pistillate varieties, frost, destruction of the flowers by molds in wet weather and in crowded beds, and destruction of pollen by the weevil prevent seed formation and consequently the development of the fruit. See Bulletin 211 of this Experiment Station (13).

Sugar cane seed is not produced by some varieties, and in others it is small and lacking in vitality.

Sunflower. Sparrows and other birds are the principal hindrance to seed growing.

Sweet pea. A damp rainy climate is unfavorable to seed production. The Spencer type may cross easily with others; but the other kinds are nearly always self pollinated. With the best of care with regard to crossing some varieties have to be rogued a great deal to keep them pure (346).

Sweet potato. Except in the Southern States, the season is too short even for flowers to form.

Tea. See 189.

Tulip tree. Seeds are produced abundantly but only a small percentage of them germinate. Those from young trees are often worthless, and only the upper ones from old trees are good (216).

Turnip varieties cross easily with each other and with rutabaga, cabbage, etc. Turnip diseases are about the same as those of cabbage, which see (140, 159).

Vanilla. The flowers have to be hand-pollinated to secure a set of pods (96).

Vetch. Harvesting about the time when the lowest pods have burst, will give the greatest yield with the smallest amount of immature seed (248).

SUMMARY.

A discussion of the principal factors that interfere with the development of seeds is given, in which much of the previous work on this question is reviewed; general rules for raising good seed are included in Part I; and in Part II, the troubles of each crop are taken up more specifically, especially from the standpoint of their control. At the end a bibliography including many of the more recent or accessible publications on the subject are given. The following results of original investigations or observations are included chiefly under the various crops discussed:

1. Opportunity for farmers to save seed of many crops from their own fields and thus to secure locally adapted and disease resistant strains, is indicated.

2. Tomato, cabbage and other seeds will germinate and grow for a time under water; and tomato seeds germinate in the fermenting tomato juice.

3. Seeds of the horsenettle and perhaps others of the Solanaceae are found germinating more frequently in manure than elsewhere.

4. Seeds of a given species are much less variable in size than the plants that bear them.

5. With the usual long period of blooming and super-abundance of flowers, the ones killed by spraying trees when in bloom would not be missed.

6. Some lots of cabbage chemically treated for disinfection, developed a growth of fungi which interfered with the growth of the seedling when germinated in sterile tubes on synthetic agar. The seedlings without the fungus grew freely.

7. Cabbage seed were injured by water at 52 degrees C. for 20 min. and at 58 degrees for 10 min. Older cabbage seed was injured at lower temperatures.

8. Fresh, half-grown cowpeas will germinate. The resulting seedlings are slender and slow-growing.

9. The largest and earliest blooming plants in colonies of winter cress are nearest the center where the mother plant of the previous year grew. Winter cress seedlings grown in the greenhouse did not complete their usual cycle, but remained in the vegetative condition all summer.

10. McCormick is about the only potato variety that seeds freely here.

11. There is enough variation in infection with septoria on tomato seedlings, to give promise of a leaf blight resistant selection.

12. Seed from rotten tomatoes taken from the field often had a low percentage of germination.

13. Seeds from tomatoes ripened in the laboratory and then allowed to rot germinate better.

14. More hybrids will be included by selecting seed from the best plants in a tomato field where there has been opportunity for different varieties to cross.

15. Easy methods for securing hybrid tomato seed are given.

16. Tomatoes grown on excess of complete fertilizer and on dissolved S. C. rock flowered earlier than those on other fertilizers; and on these and the ones on excess of potash, there were somewhat fewer leaves below the first flowers.

17. Seed from green tomatoes will germinate, but the greener the seed, the longer before germination.

18. Seeds from tomatoes immature when the leaves were killed by frost Oct. 14. still germinated well when taken from the field up to

Nov. 9, withstanding a nuumber of heavy frosts and with temperatures as low as 15 degrees F.

19. Five days fermentation of tomato pulp did not affect the germination but after that there was a rapid falling off in vitality.

20. Tomato seed blackened by drying on copper screens were not lowered in vitality. Seed from which the embryo had begun to protrude due to too slow drying, after full drying did not show any reduction in germination.

21. The seeds of beech nut grown in this region are usually abortive.

22. Broad-beans scarcely ever set seed here.

23. Opportunity to select early and full-berried strains of holly, and strains of crucifers with less tendency to bloom too soon, are indicated.

LIST OF PUBLICATIONS CITED.

Most of the abbreviations used below are self-explanatory. The publications of the various State experiment stations are cited as follows: Conn. Bul. 21, 1895; Md. Circ. 17, 1912; Del. Rept. 7, 1898, etc., for Bulletins, Circulars and Annual Reports, respectively, of the Connecticut, Maryland and Delaware Agricultural Experiment Stations. U. S. D. A. is used for United States Department of Agriculture; Farm. Bul. for Farmers' Bulletin of U. S. D. A. and B. P. I. for Bureau of Plant Industry. Most of the foreign titles have been translated into English.

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